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CH2MHILL

Bunker Hill Mine Water Presumptive Remedy

Sludge Management

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Purpose

- Evaluate sludge management options for sludge generated from treatment of Bunker Hill AMD

Objectives

- Identify potential sludge treatment and disposal options
- Develop options to a conceptual design level
- Prepare order-of-magnitude cost estimates for options
- Evaluate options based on implementability, effectiveness, and cost
- Assemble options into alternatives

Design Basis

- Dewatered HDS sludge physical properties and quantities

Parameter	Sludge Drying Beds	Belt Filter Press
Final Percent Solids (by weight)	60	40
Sludge Specific Gravity	1.81	1.43
Average Sludge Production Rate (yd^3/year)	5,400	10,300
Average Sludge Production Rate (tons/year)	8,200	12,300
Maximum Sludge Production Rate (yd^3/year)	7,500	14,300
Maximum Sludge Production Rate (tons/year)	11,400	17,100

Design Basis

- Estimated composition of sludge

Major Component	Approximate Dry Weight Percent
Iron Oxides and Hydroxides	25
Zinc Oxides and Hydroxides	25
Manganese Oxides and Hydroxides	22
Gypsum ($CaSO_4 \cdot 2H_2O$)	14
Magnesium Oxides and Hydroxides	12
Aluminum Oxides and Hydroxides	2

Potential AMD Treatment Processes

- HDS followed by media filters
- HDS followed by microfilters
- HDS followed by iron coprecipitation and media or microfilters
- HDS followed by sulfide precipitation and media or microfilters
- HDS followed by microfilters and sulfide functional ion exchange
- Sulfide addition to HDS followed by media filters
- HDS followed by evaporation and crystallization

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HDS Sludge Management Options

- Raw Sludge Disposal Options
  - *Raise No. 3*
  - *Sludge Disposal Beds*
- Raw Sludge Dewatering Options
  - *Belt Filter Press*
  - *Sludge Dewatering Beds*
- Dewatered Sludge Disposal Options
  - *Hanna Stope*
  - *Onsite Landfill*
  - *Offsite Landfill*
- Metal Recovery

Disposal in Raise No. 3

- (Insert Figure 1)

Disposal in Raise No. 3

- (Insert Figure 2)- Aerial Photo

Disposal in Raise No. 3

- Sludge Disposal Volume = 18,500 cubic yards
- Capacity equivalent to approximately 1.5 years of sludge production
- Total NPV = $2,300,000
- Option is implementable with limited effectiveness

Disposal in Raise No. 3

- Advantages
  - Potential low cost option
- Disadvantages
  - Limited storage capacity
  - Severe (costly) mine infrastructure impact
- Option is NOT retained

Onsite Sludge Disposal Beds

- (Insert Figure 3)

Onsite Sludge Disposal Beds

- Three cells each with 10-year capacity
- 55,000 cubic yards capacity for each cell
- NPV = $6,280,000
- Option is implementable and effective

Onsite Sludge Disposal Beds

- (Insert Figure 4)- Site Locations

Onsite Sludge Disposal Beds

- Advantages
  - Combines dewatering and disposal into single step
  - Proven method of disposal
- Disadvantages
  - Design and construction must interface with CIA closure
  - Will occupy 12 acres of the CIA
- Option is Retained

HDS Sludge Management Options

- Raw Sludge Disposal Options
  - *Raise No. 3*
  - *Sludge Disposal Beds*
- **Raw Sludge Dewatering Options**
  - ***Belt Filter Press***
  - ***Sludge Dewatering Beds***
- Dewatered Sludge Disposal Options
  - *Hanna Stope*
  - *Onsite Landfill*
  - *Offsite Landfill*
- Metal Recovery

Belt Filter Press

- (Insert Figure 6)

Belt Filter Press

- 4 Belt Filter Presses with building
- Product estimated at 40 percent solids
- NPV = $6,260,000
- Option is implementable and effective

Belt Filter Press

- Advantages
  - Requires less energy, easier to maintain, and smaller footprint than other mechanical dewatering options
  - Small area requirements
- Disadvantages
  - Requires trained operator
  - Extensive support system compared to non-mechanical methods
  - Lower percent solids compared to drying beds
  - Linkage between sludge production and sludge haulage
- Option is Retained

Onsite Sludge Drying Beds

- (Insert Figure 7)

Onsite Sludge Drying Beds

- Two beds each with 12-month capacity
- 10,000 cubic yards per cell
- Product estimated at 60 percent solids
- NPV = $2,150,000
- Option is implementable and effective

Onsite Sludge Drying Beds

- (Insert Figure 8)- Site Location

Onsite Sludge Drying Beds

- Advantages
  - Low O&M costs
  - Lower cost and simpler operation compared to belt filter press
  - Proven method for dewatering
- Disadvantages
  - Design and construction must interface with CIA Closure
  - Will take up 3 acres of CIA
  - Requires additional step of excavating and hauling dewatered sludge
- Option is Retained

HDS Sludge Management Options

- Raw Sludge Disposal Options
  - *Raise No. 3*
  - *Sludge Disposal Beds*
- Raw Sludge Dewatering Options
  - *Belt Filter Press*
  - *Sludge Dewatering Beds*
- **Dewatered Sludge Disposal Options**
  - ***Hanna Stope***
  - ***Onsite Landfill***
  - ***Offsite Landfill***
- Metal Recovery

Hanna Stope

- (Insert Figure 10)

Dewatered Sludge Disposal Options

- (Insert Figure 2)-Aerial Photo

Hanna Stope

- Sludge Disposal Volume = 780,000 cubic yards?
- Equivalent to more than 30 years of sludge production
- Total NPV = ?
- High level of uncertainty
  - Implementability
  - Effectiveness

Hanna Stope

- (Insert Figure 11)-Uncertainties

Could we pump up to Hanna?

15,000 ft linear from CTP
700 ft elevation

Hanna Stope

- Advantages
  - Potentially lower cost than disposal in an Offsite Landfill
  - Does not use land within Kellogg that could be used for other purposes
- Disadvantages
  - High number of trucks hauling sludge annually
  - Uncertainties in implementation and effectiveness
- Option is NOT Retained

Hanna Stope

- Additional Data Needs
  - Develop stope drainage system
  - Verify plug locations
  - Develop drift rehabilitation costs
- Drainage System Issues
  - Rerouting major flows
  - Effective drainage as stope is filled with sludge
  - Construction in protected areas

Onsite Landfill

- Site Locations that were considered
  - Portal Gulch
  - Industrial Flats
  - Deadwood Gulch
  - Magnet Gulch
  - A4 Gypsum Pond
  - Vista Hill
  - *Government Gulch
  - Demo Landfill Area
  - *Central Impoundment Area

Onsite Landfill

- (Insert Figure 12)- Alternative Site Locations

Onsite Landfill

- (Insert Figure 13)

Onsite Landfill

- Capacity of 203,000 cubic yards
- Equivalent to 30-year storage capacity
- CIA Flat Area Site
  - NPV = $3,530,000
- Government Gulch Area Site
  - NPV = $5,470,000
- Options are implementable and effective

Onsite Landfill

- Flat Area Advantages
  - Easier access and constructibility
  - Lower risk from storm water
  - Higher stability
- Gulch Area Advantages
  - Uses less developable land
- Options Retained

Offsite Landfill

- Dewatered sludge assumed to meet all State and Federal Toxicity Criteria for disposal in a Subtitle D facility
- Location alternatives
  - Chemical Waste Management
    - *Arlington, OR*
    - *Graham Road in Airway Heights, WA*
  - Robanco
    - *Roosevelt, WA*

Offsite Landfill

- Disposal costs

Sludge Type	Airway Heights, WA Graham Road ($35/ton)	Arlington, OR Chemical Waste Management ($50/ton)	Roosevelt, WA Rabanco ($52/ton)
Belt Filter Press Sludge (12,400 tons/year)	477,000/year 7,330,000 NPV	682,000/year 10,500,000 NPV	709,000/year 10,900,000 NPV
Drying Bed Sludge (8,200 tons/year)	346,000/year 5,320,000 NPV	481,000/year 7,390,000 NPV	499,000/year 7,670,000 NPV

Offsite Landfill

- Option is implementable and effective
- Advantages
  - Offsite landfilling does not use land within Kellogg that could be used for other purposes
- Disadvantages
  - Truck noise and wear-and-tear on the roads
  - High costs
- Option is retained

HDS Sludge Management Options

- Raw Sludge Disposal Options
  - *Raise No. 3*
  - *Sludge Disposal Beds*
- Raw Sludge Dewatering Options
  - *Belt Filter Press*
  - *Sludge Dewatering Beds*
- Dewatered Sludge Disposal Options
  - *Hanna Stope*
  - *Onsite Landfill*
  - *Offsite Landfill*
- **Metal Recovery**

By-Product Metal Recovery Options

- Processing of Raw AMD
  - Selective precipitation
  - Sorptive processes
- Processing of HDS Sludge
  - Process developed by Pesic et al.

Metal from HDS Sludge Process

- Sludge Leaching (H_2SO_4 and SO_2)
- Solution Purification
- Electrowinning (Zn metal and MnO_2)

Metal from HDS Sludge Process

- Design capacity = 125 percent of annual average sludge production rate
- Use conceptual process scheme proposed by Pesic, et al.
- Zinc production rate = 1,200 tons per year
- Manganese dioxide production rate = 600 tons per year
- Residual sludge = 4,100 tons per year

- Need to rehab the Russell Tunnel
- 3 plugs probably

Metal Recovery Cost

- Capital Cost = $8,400,000
- Net Operating Revenue = $300,000/yr.
- NPV = $3,690,000
- Costs sensitive to metal price, sludge production rate, and metal content of sludge

Metal from HDS Sludge

- Process demonstrated at laboratory scale
- Effective at recovering Zn and Mn
- Pilot testing would be required
- Costs have higher level of uncertainty than other disposal options
- Option retained

Disposal Options for Evaporator and Crystallizer Sludge

- Hanna Stope
  - NPV = $6,200,000
- Onsite Landfill
  - NPV = $12,000,000
- Offsite Landfill
  - NPV = $12,600,000

Assembly of Alternatives

- Alternative 1
  - Onsite Disposal Beds
- Alternative 2
  - Sludge Drying Beds and Flat Area Onsite Landfill
- Alternative 3
  - Sludge Drying Beds and Offsite Landfill
- Alternative 4
  - Belt Filter Press and Offsite Landfill
- Alternative 5
  - Sludge Drying Beds, Metal Recovery, and Offsite Landfill

Evaluation of Sludge Management Alternatives

	Description	Cost (Total 30-yr NPV)
Alternative 1	Onsite Sludge Disposal Beds	$6,280,000
Alternative 2	Sludge Drying Beds and Onsite Flat Area Landfill	$7,960,000
Alternative 3	Sludge Drying Beds and Offsite Landfill	$9,550,000
Alternative 4	Belt Filter Presses and disposal in an Offsite Landfill	$13,600,000
Alternative 5	Sludge Drying Beds, Sludge Metal Recovery, and Offsite Landfill	$5,840,000

Alternative Summary

- Two lowest cost alternatives that are both implementable and effective
  - Alternative 1
    - *Disposal of raw sludge in Onsite Drying Beds*
  - Alternative 2
    - *Dewatering with Onsite Drying Beds, sludge metal recovery, and disposal in an Offsite Landfill.*

Alternative Summary

- Alternative 1
  - Proven low cost alternative
  - Well established technology and well defined costs
- Alternative 5
  - Potential to be lower cost with recovery of metals
  - Process demonstrated in laboratory only
  - Costs have a higher level of uncertainty

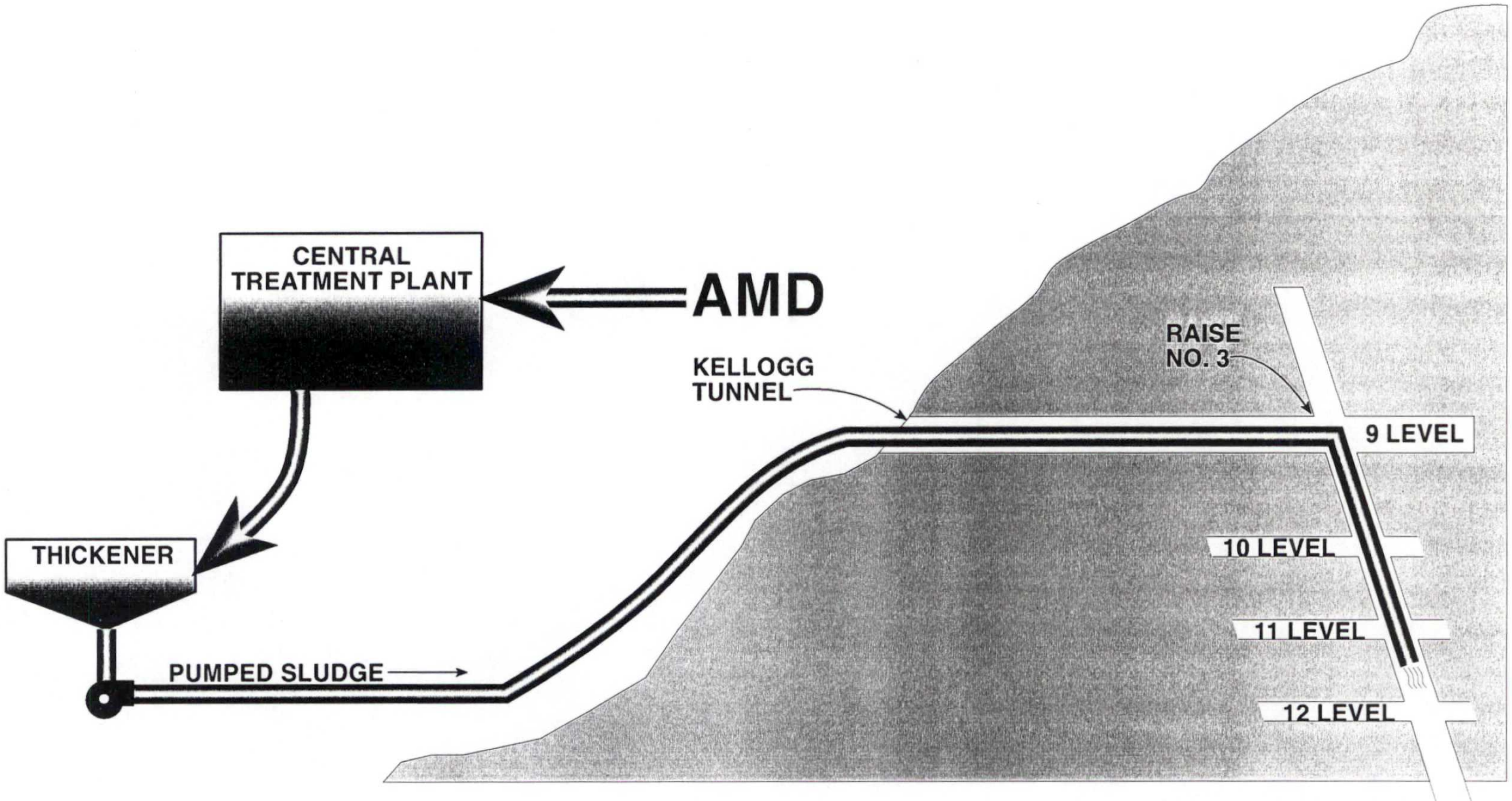

FIGURE 1
PUMPING OF RAW SLUDGE TO RAISE NO. 3 FOR DISPOSAL
BUNKER HILL MINE WATER MANAGEMENT

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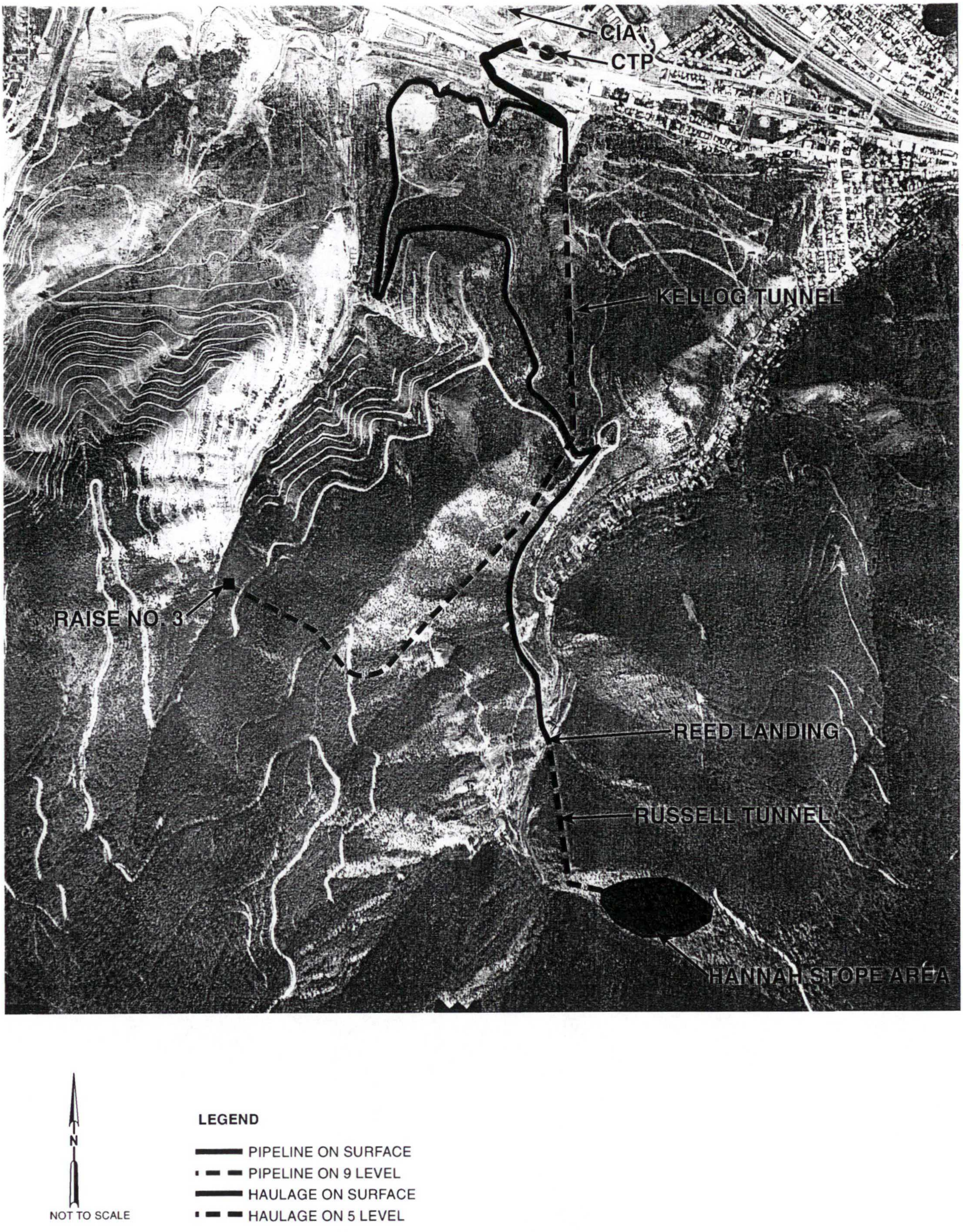

FIGURE 2
ROUTING OF PIPELINE AND TRUCK HAULAGE FOR IN-MINE SLUDGE DISPOSAL
BUNKER HILL MINE WATER MANAGEMENT
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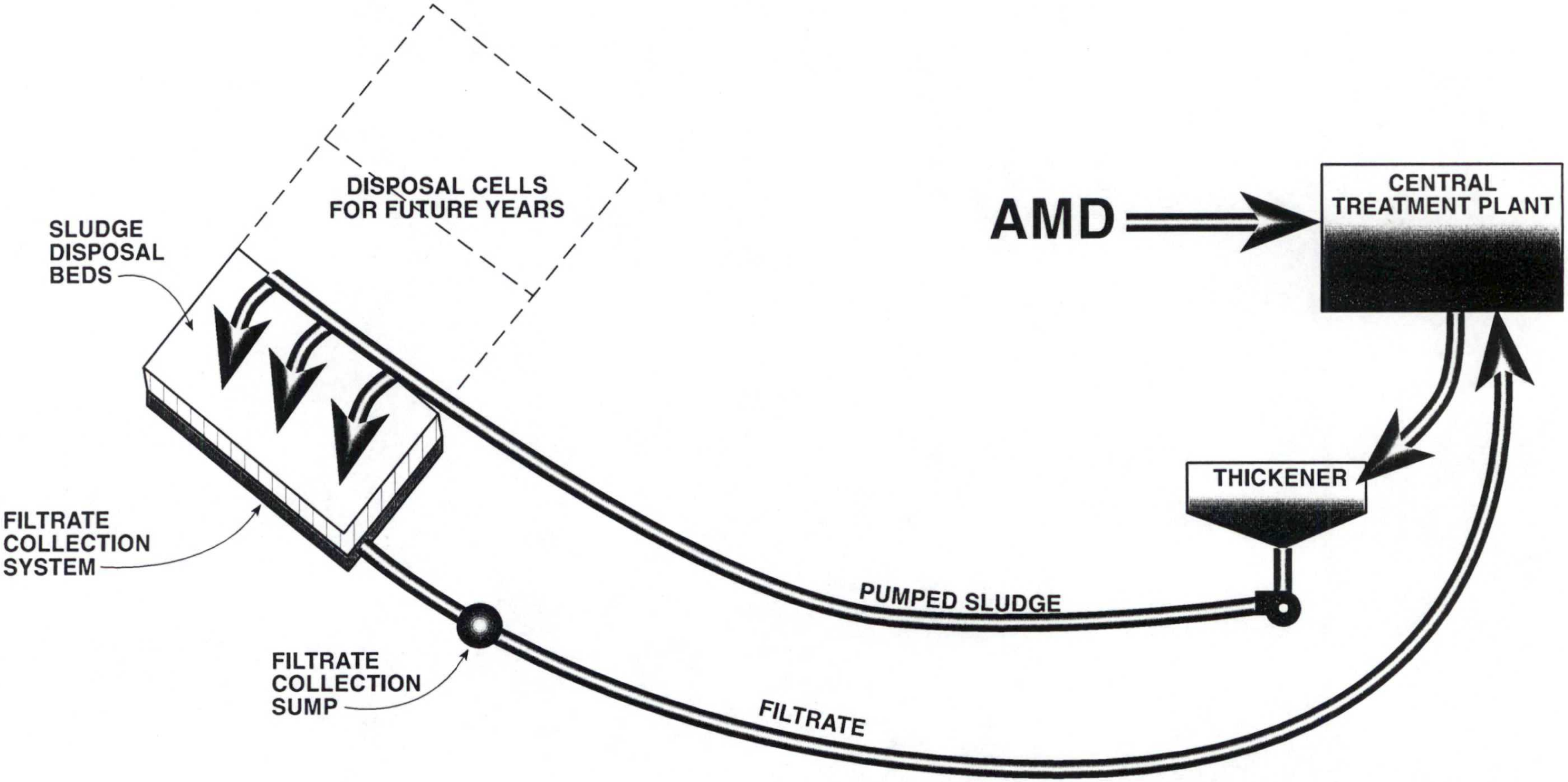

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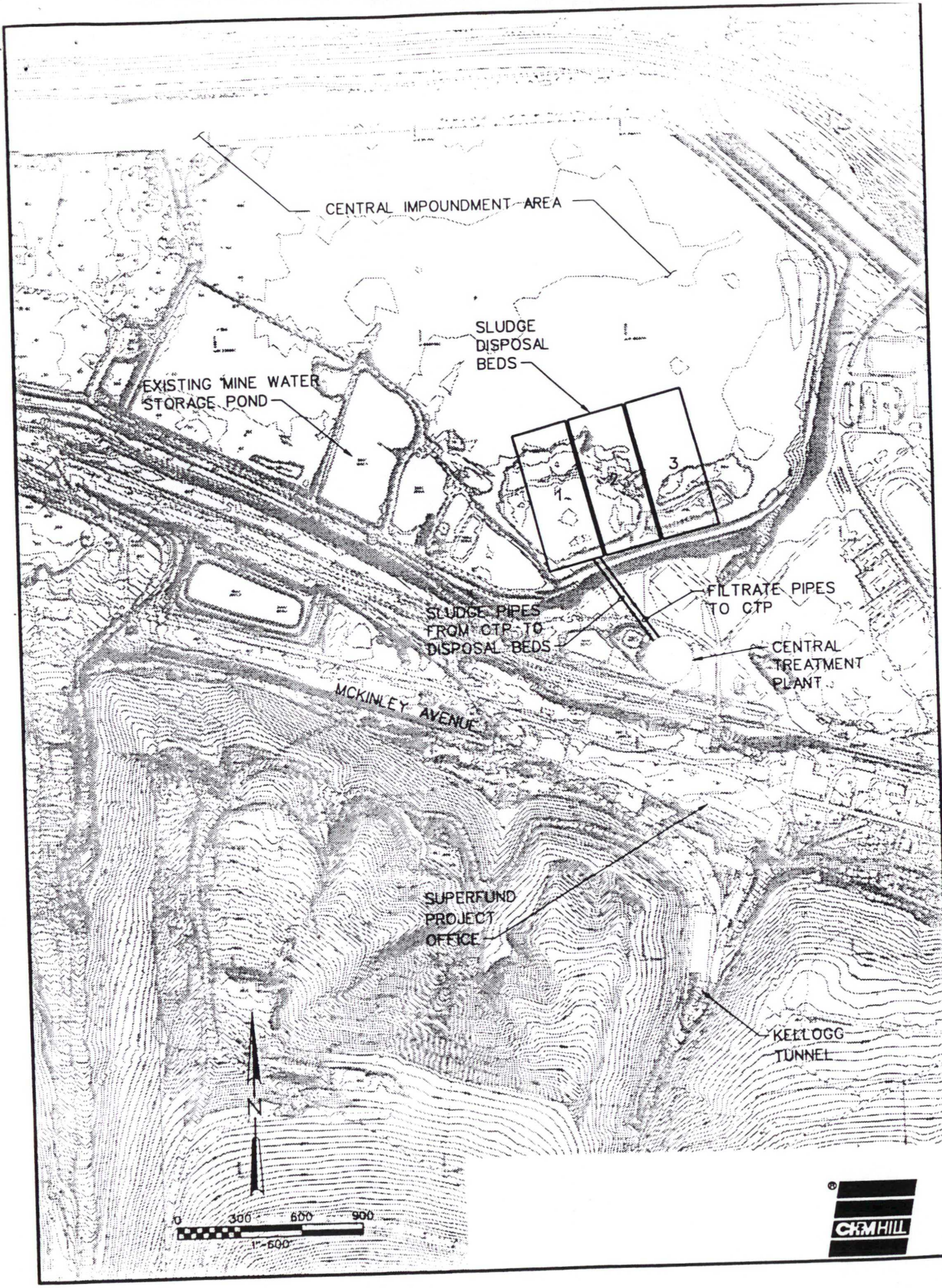
FIGURE 3
SLUDGE DISPOSAL BEDS
BUNKER HILL MINE WATER MANAGEMENT



PRELIMINARY

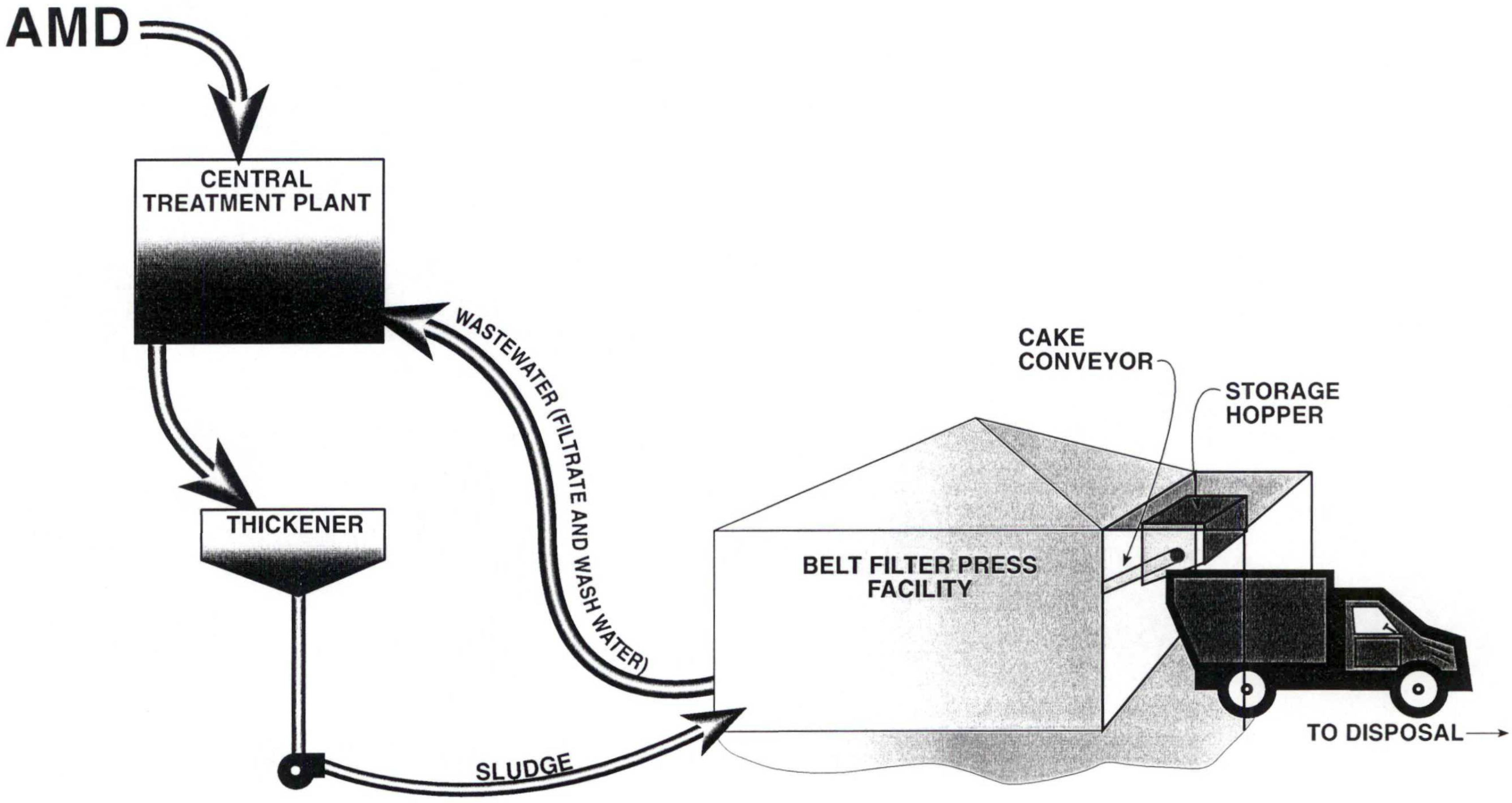


FIGURE 6
DEWATERING OF SLUDGE WITH BELT FILTER PRESS
BUNKER HILL MINE WATER MANAGEMENT

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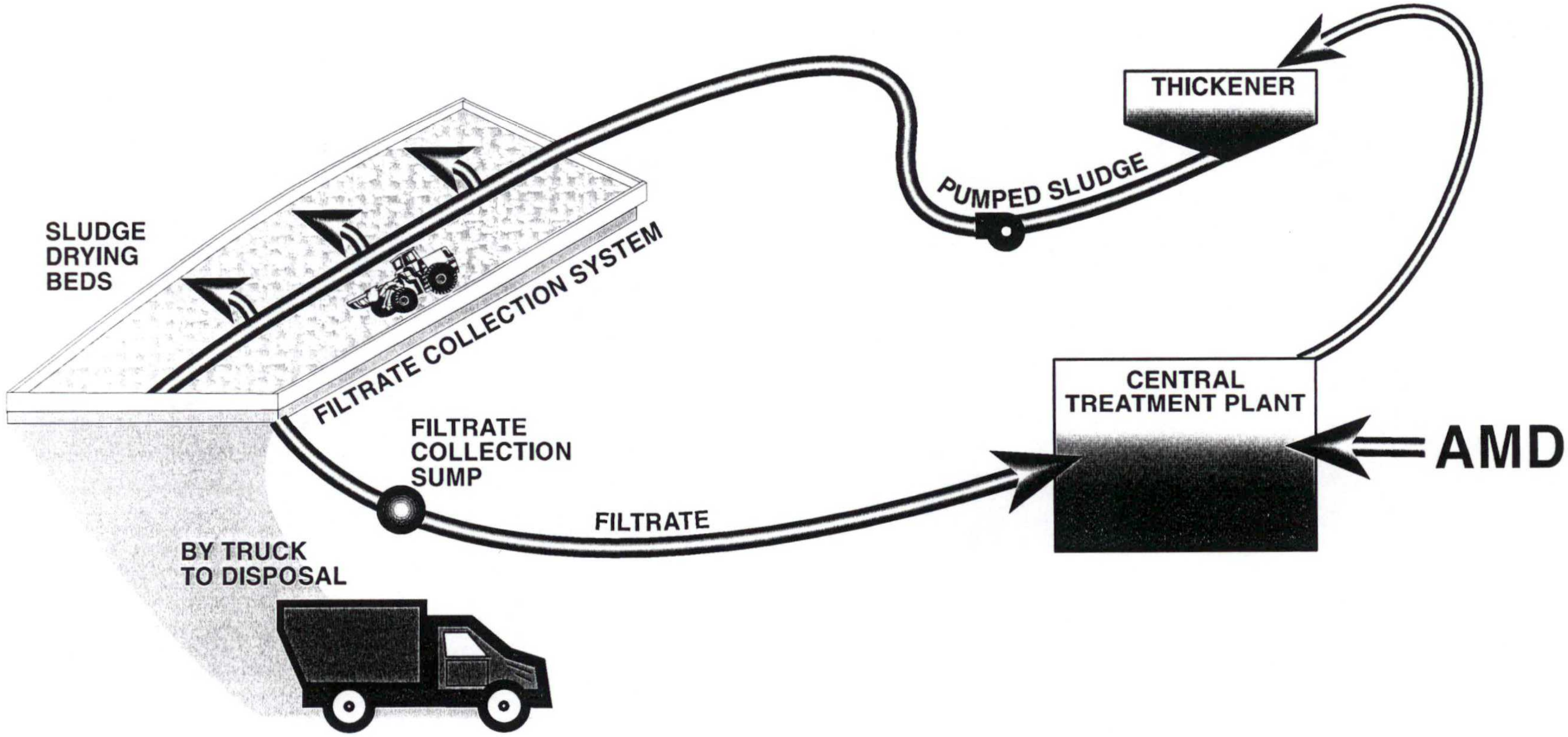

FIGURE 7
DEWATERING OF SLUDGE USING SLUDGE DRYING BEDS
BUNKER HILL MINE WATER MANAGEMENT

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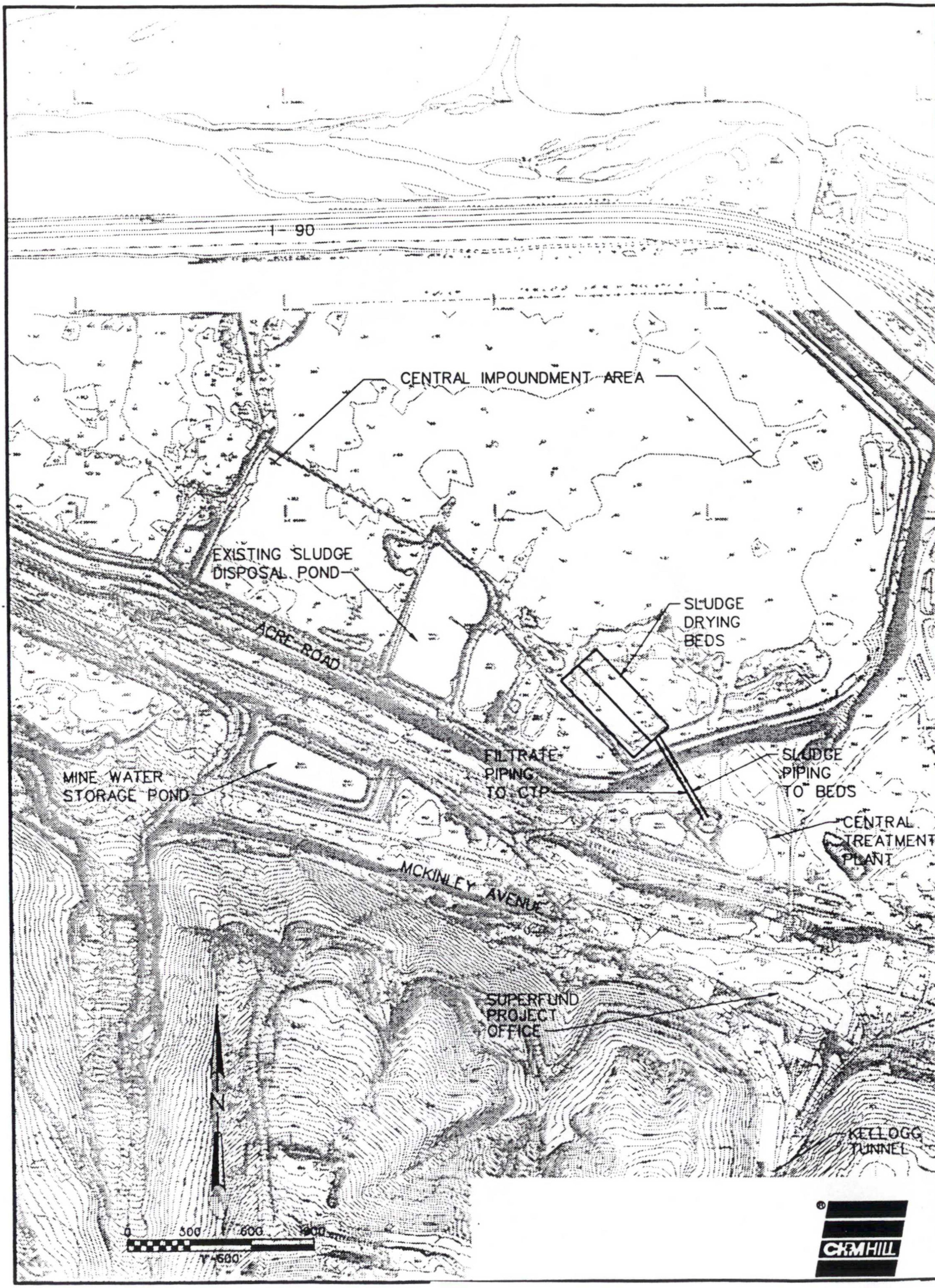


PRELIMINARY

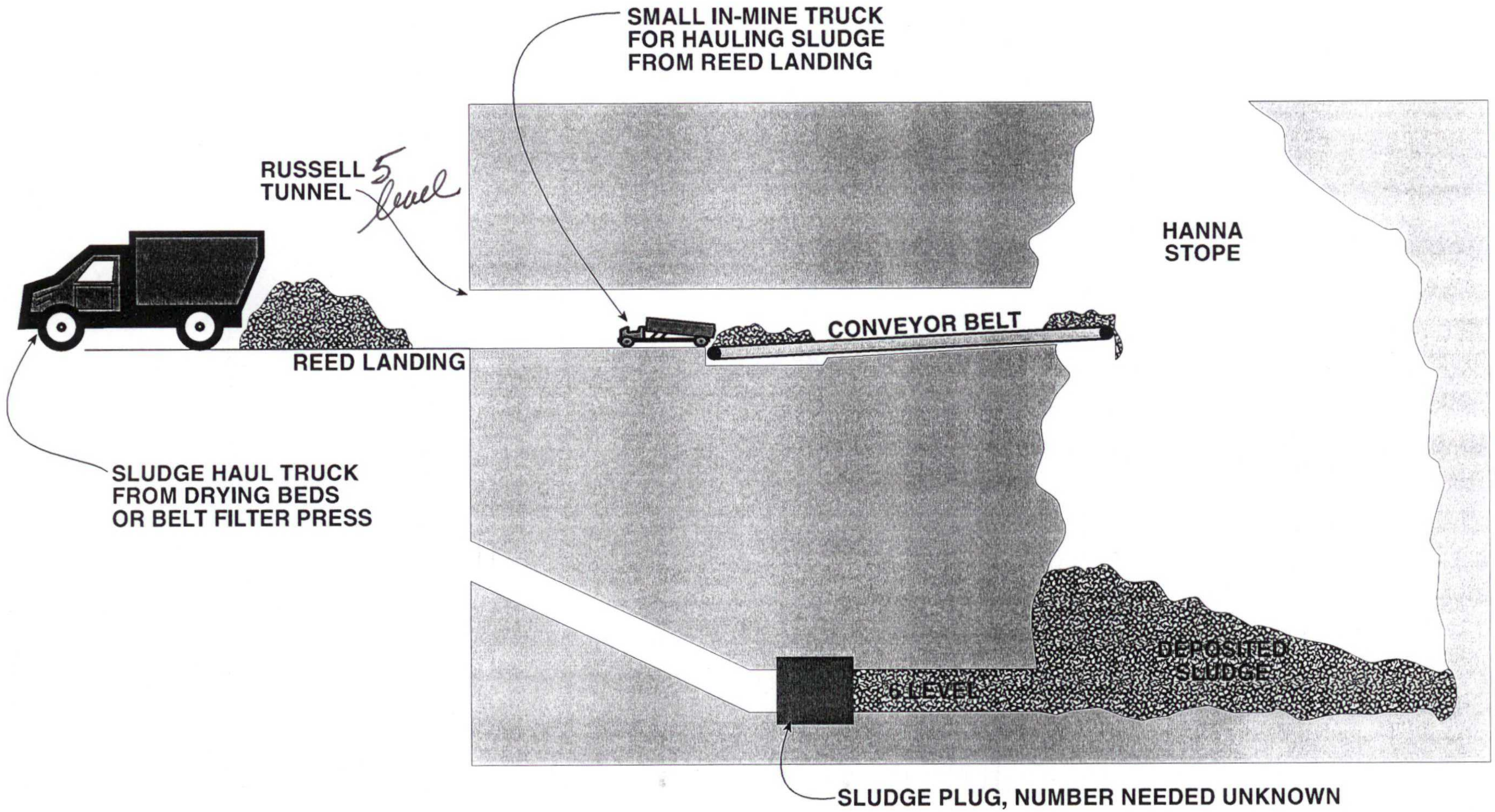
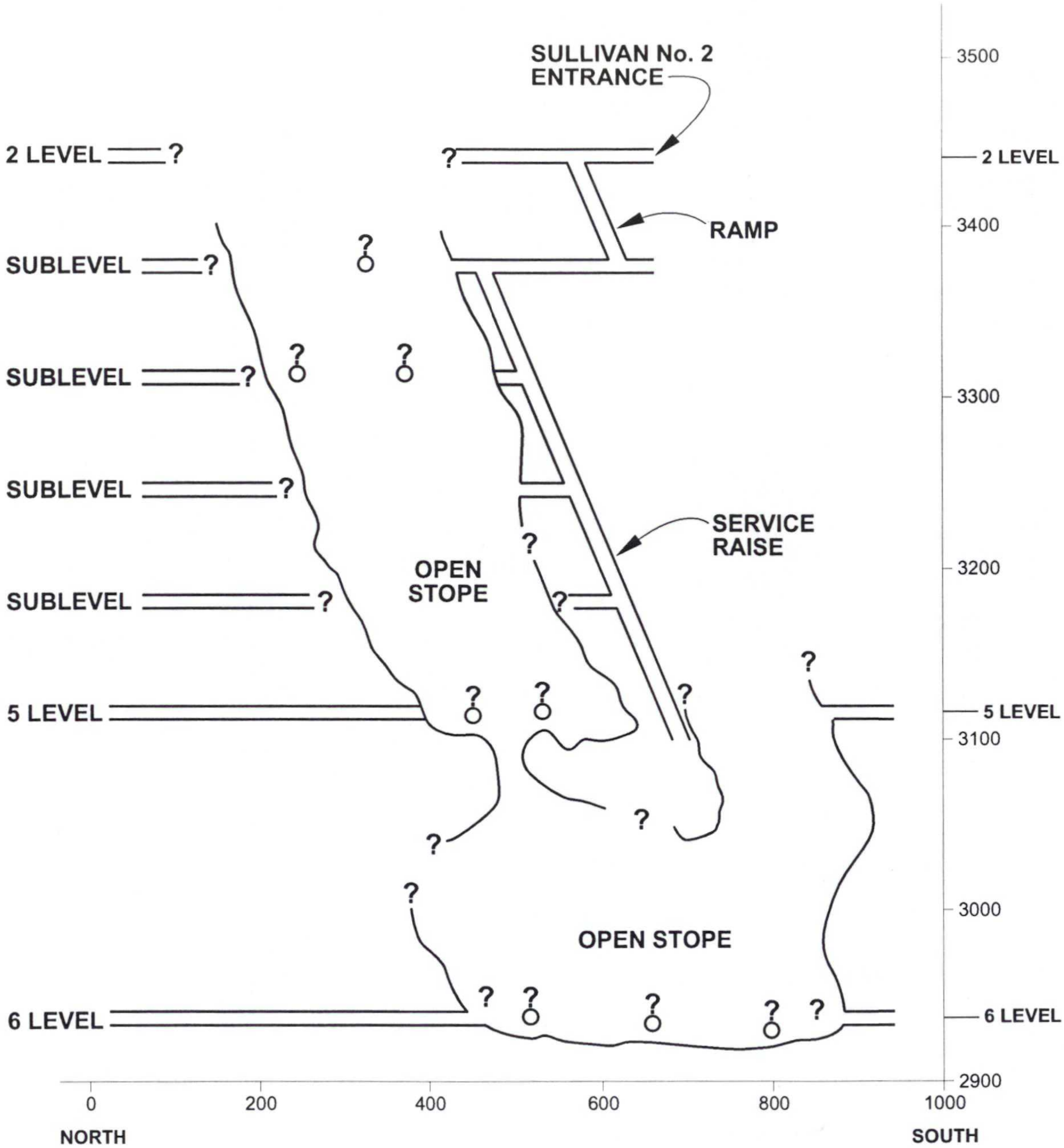


FIGURE 10
DISPOSAL OF DEWATERED SLUDGE IN HANNA STOPE
BUNKER HILL MINE WATER MANAGEMENT

2605_04 (12/15/98)



NOTE
THE SIZE, CONFIGURATION, LOCATION, AND CONDITION OF THE STOPE IS NOT WELL UNDERSTOOD OR DOCUMENTED. THIS CONCEPTUAL SKETCH WAS MADE AFTER TWO ONE-DAY RECONNAISSANCE TRIPS

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FIGURE 11
CONCEPTUAL CROSS SECTION SKETCH OF HANNA STOPE
BUNKER HILL MINE WATER MANAGEMENT


SITE ACCESS GATE
SWEENEY PUMP STATION
CENTRAL IMPOUNDMENT AREA
A-4 GYPSUM POND SITE
CIA SITE
SMELTER COMPLEX AREA
DEMO LANDFILL SITE
MAGNET GULCH SITE
SITE ACCESS GATE AND MANNED SECURITY POST
CENTRAL TREATMENT PLANT
MCKINLEY AVENUE
FIRE CONTROL RESERVOIR
PHOSPHORIC ACID PLANT
DEADWOOD GULCH SITE
SUPERFUND PROJECT OFFICE
INDUSTRIAL FLATS SITE
VISTA HILL SITE
ZINC PLANT
PORTAL GULCH SITE
GOVERNMENT GULCH SITE

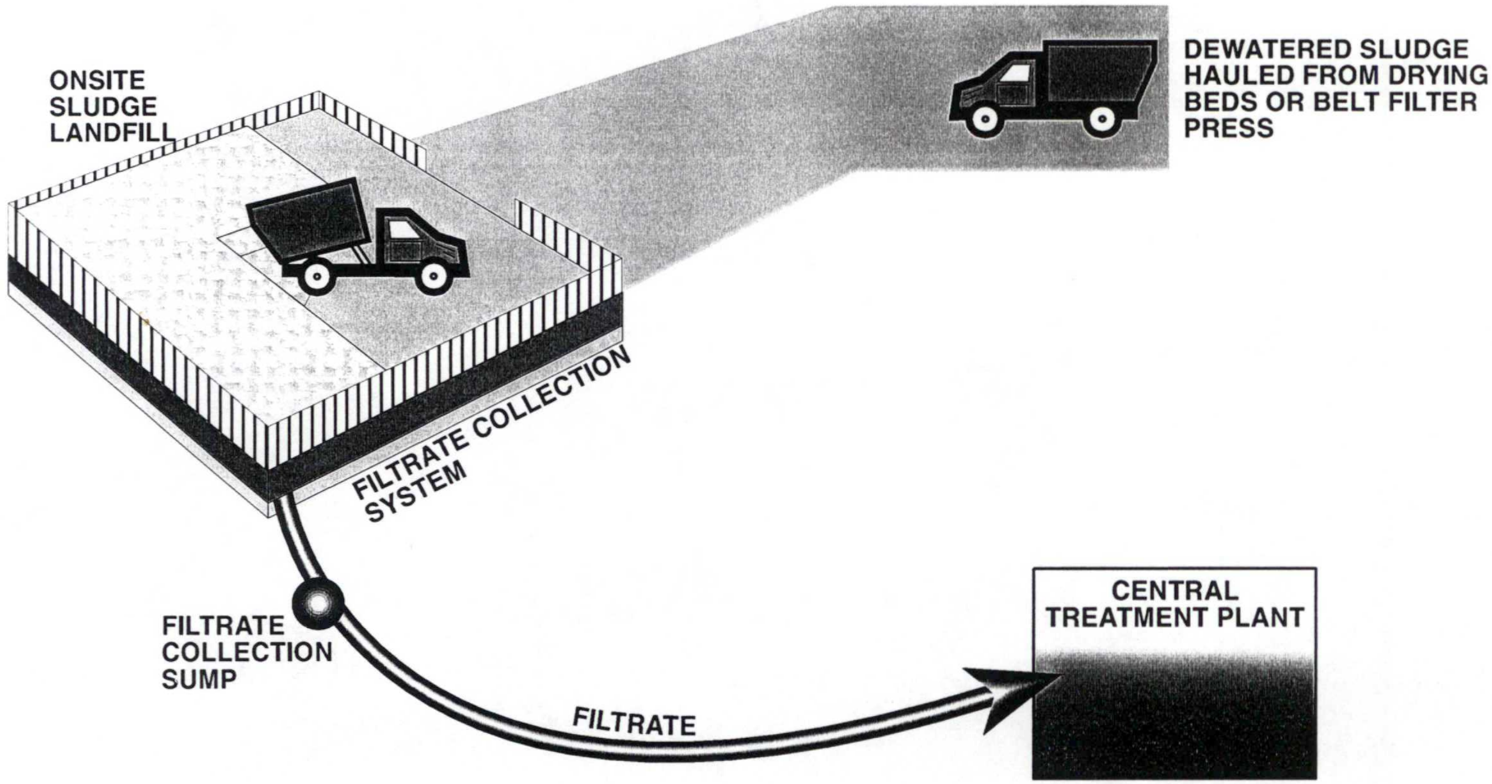

FIGURE 13
ONSITE SLUDGE LANDFILL
BUNKER HILL MINE WATER MANAGEMENT

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